



Renewable Energy Research Conference

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CEDREN

Centre for Environmental Design of Renewable Energy





Developing scenarios for large-scale balancing and storage of variable energy sources by Norwegian hydropower

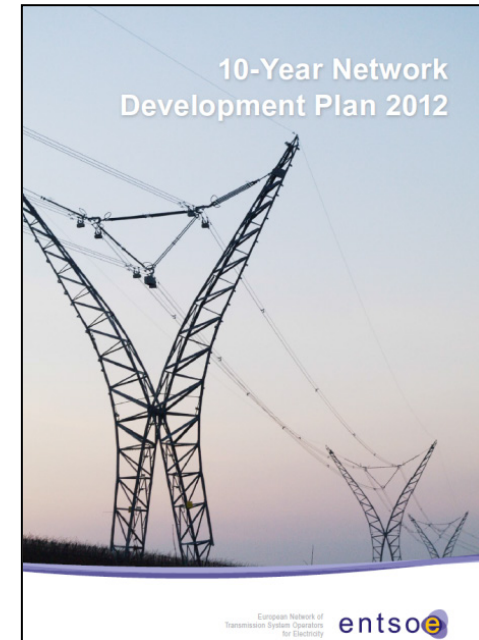
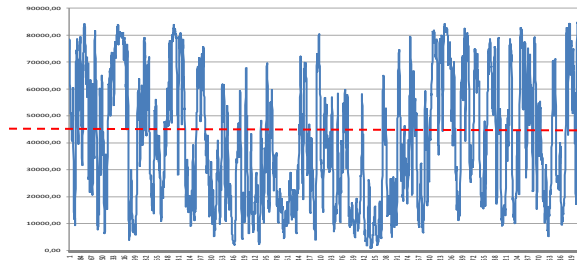
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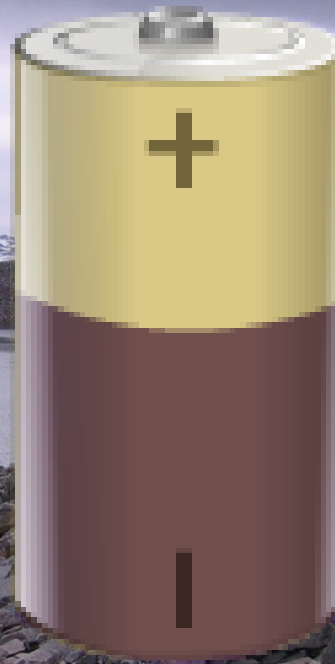


Integration of VRES

- Transmission and distribution grid expansion
- Demand side management
- Improved forecasting of resource availability
- Energy storage

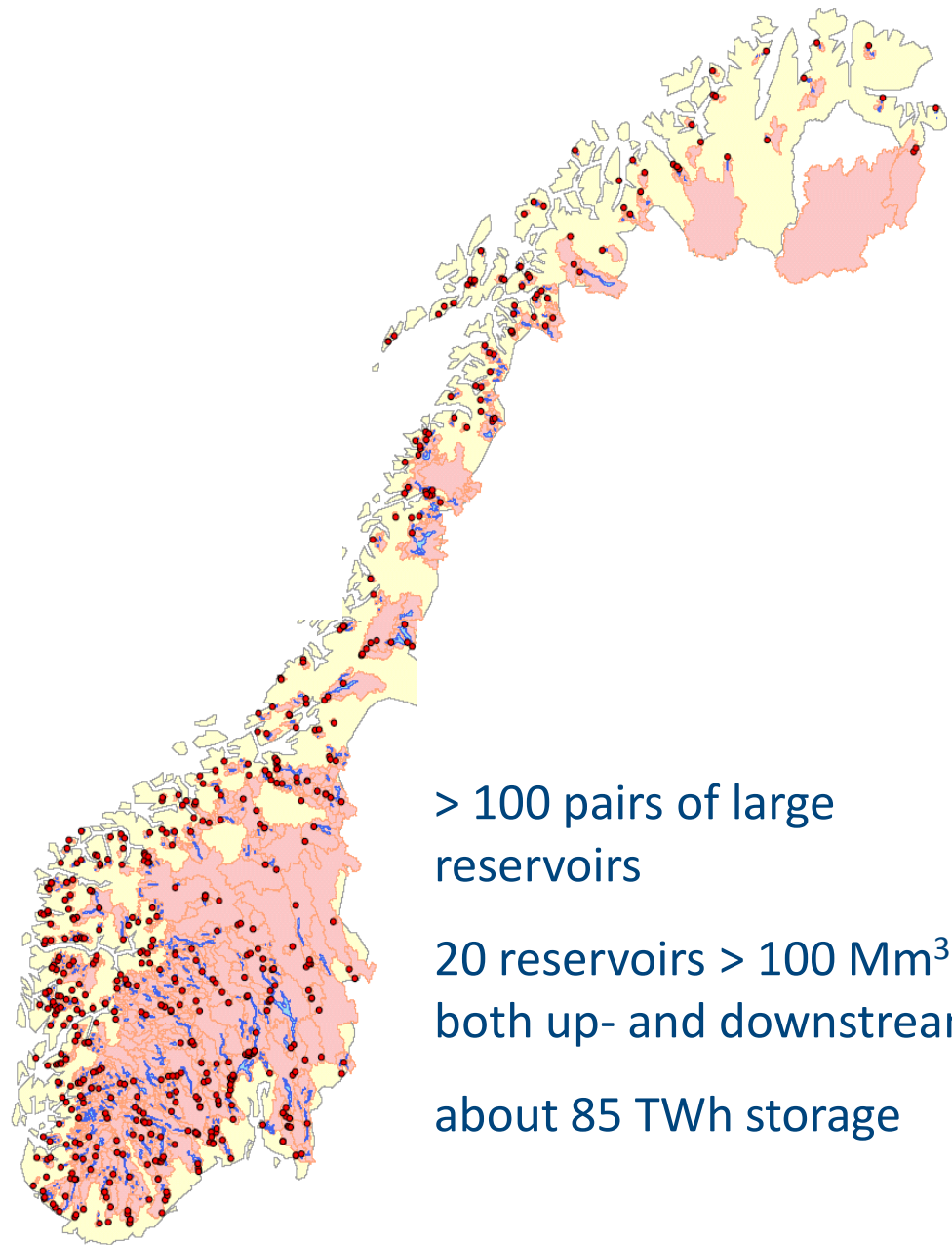


Hydro storage –
a renewable battery



Hydropower in Norway

- Number of reservoirs
- Storage capacity



> 100 pairs of large reservoirs

20 reservoirs > 100 Mm³
both up- and downstream

about 85 TWh storage

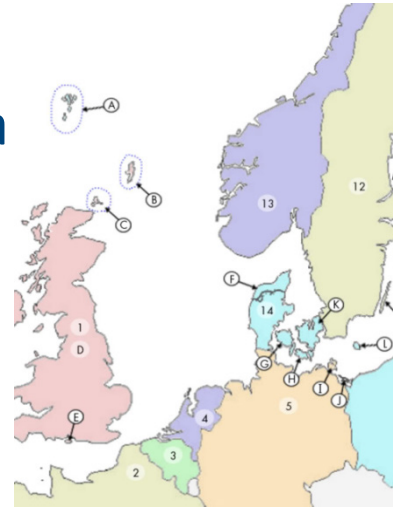
HydroBalance Project



- Scenarios for different futures of the Norwegian hydro system
- Roadmap
- Analyses, simulations and case studies of
 - energy system
 - energy market
 - environmental impacts
 - regulatory framework and public acceptance

HydroBalance scenarios

- **Geographic extent:** Northern Europe, North Sea area
Focus area = NO, SE, DK, UK,
FR, BE, NL, DE, + rest of EU

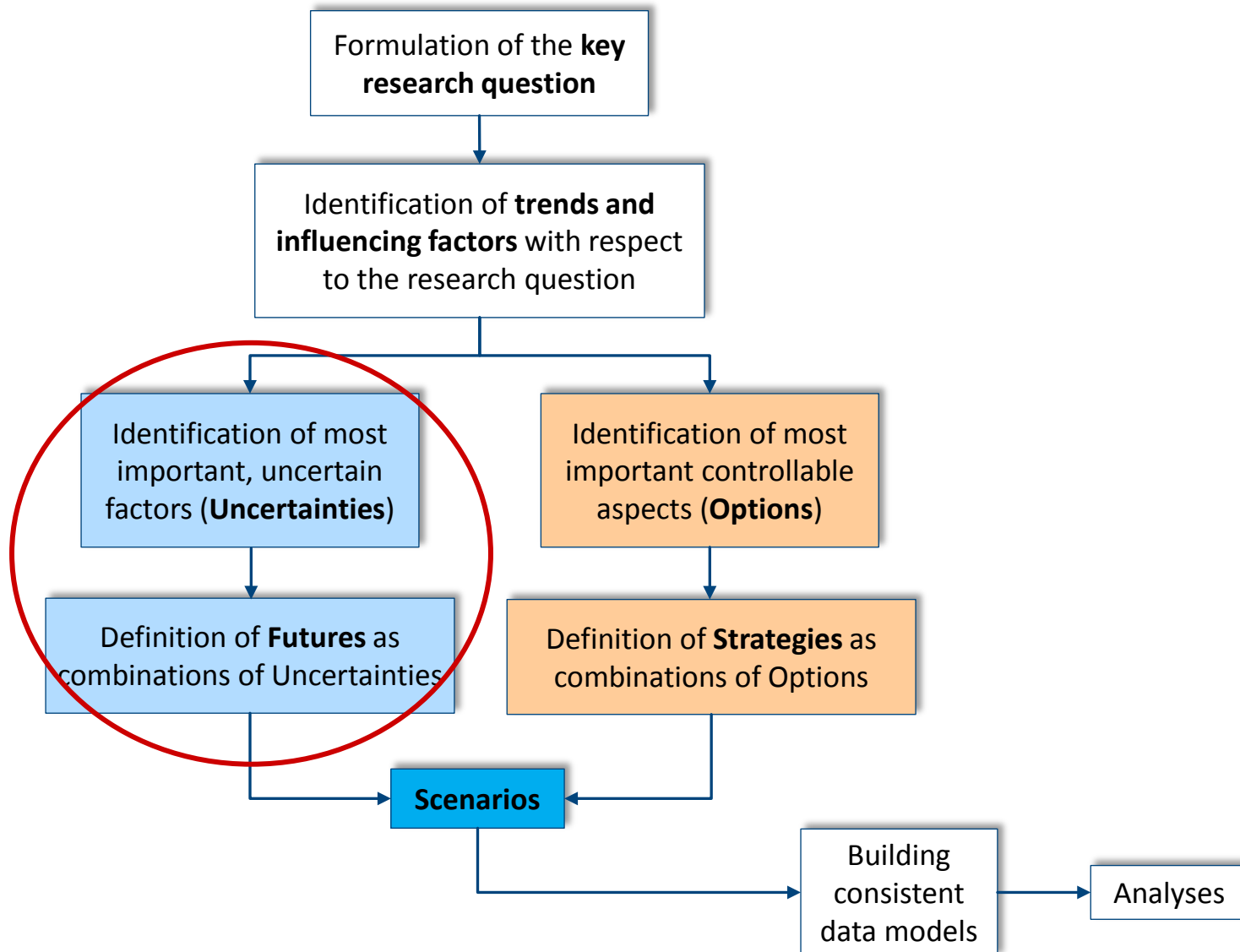


Picture: http://i1232.photobucket.com/albums/ff367/diving8/map_north-sea_enlarged.jpg

- **Time horizon:**  2050
- **Key question:**

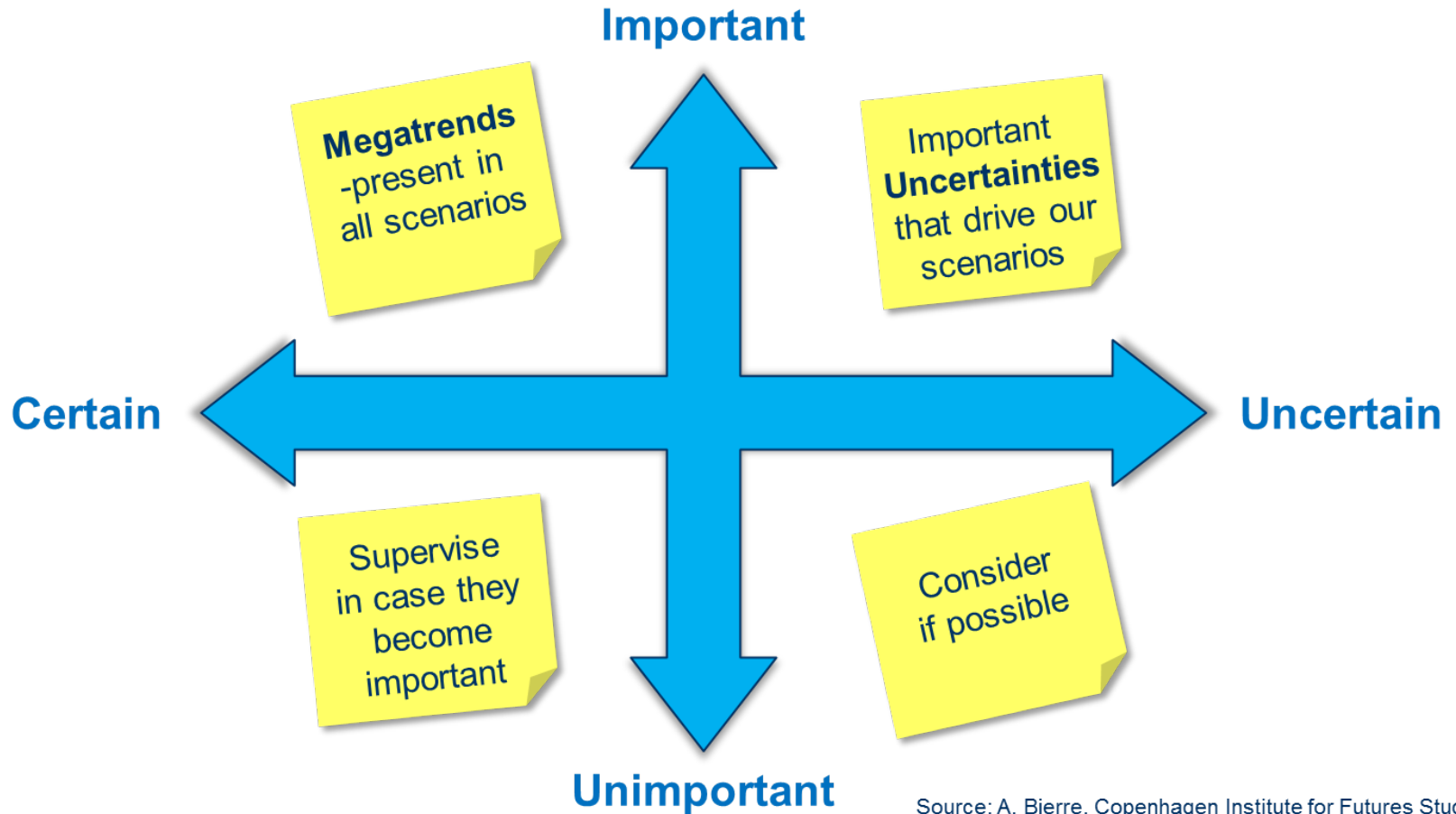
Which role can energy balancing and storage by Norwegian hydropower play in the future European electricity market?

Scenario building approach



Scenario building approach

- Identification of **most important uncertainties**



Source: A. Bjerre, Copenhagen Institute for Futures Studies

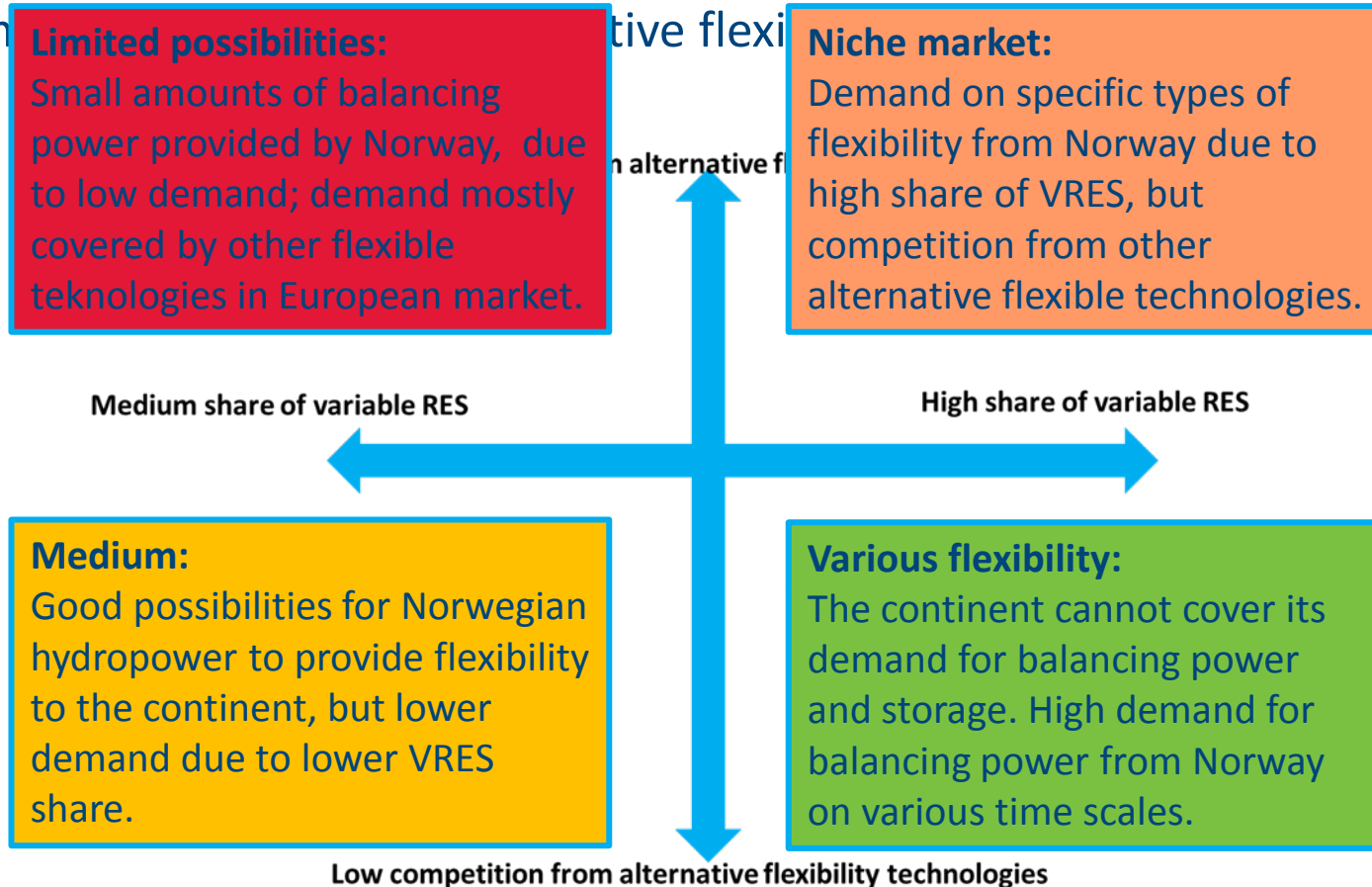
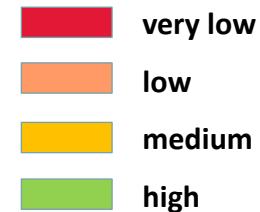
Results from the workshop (I)

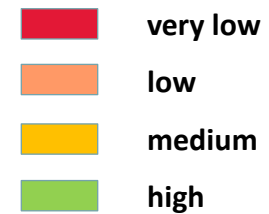
Most important uncertainties:

1. Share of variable renewable energies (VRES)

2. Competition from alternative flexible technologies

Colour code: Amount of balancing and storage provided by Norwegian hydro





Results from the workshop (II)

Most important uncertainties:

1. **Fully integrated B:**
2. Good possibilities for providing flexibility to the continent on EU and national level. Low competition gives large demand for balancing and storage from Norwegian hydro.
- 3.

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Integration

Fully integrated A:

Good possibilities for providing flexibility to the continent, but lower demand due to competition with other technologies providing flexibility.

Non-interested Norway B:

EU establishes integrated markets and strengthens grids. Norway does not build further interconnectors . Alternative technologies are not competitive; EU faces high costs to cover the demand.

Non-interested Norway A:

EU establishes integrated markets and strengthens grids. Norway does not build further interconnectors; demand is covered by other technologies.

Nationalism B:

EU policy leads to national markets. High demand for flexibility from Norway due to low competition. Norway promotes interconnection with EU through bilateral agreements.

Nationalism

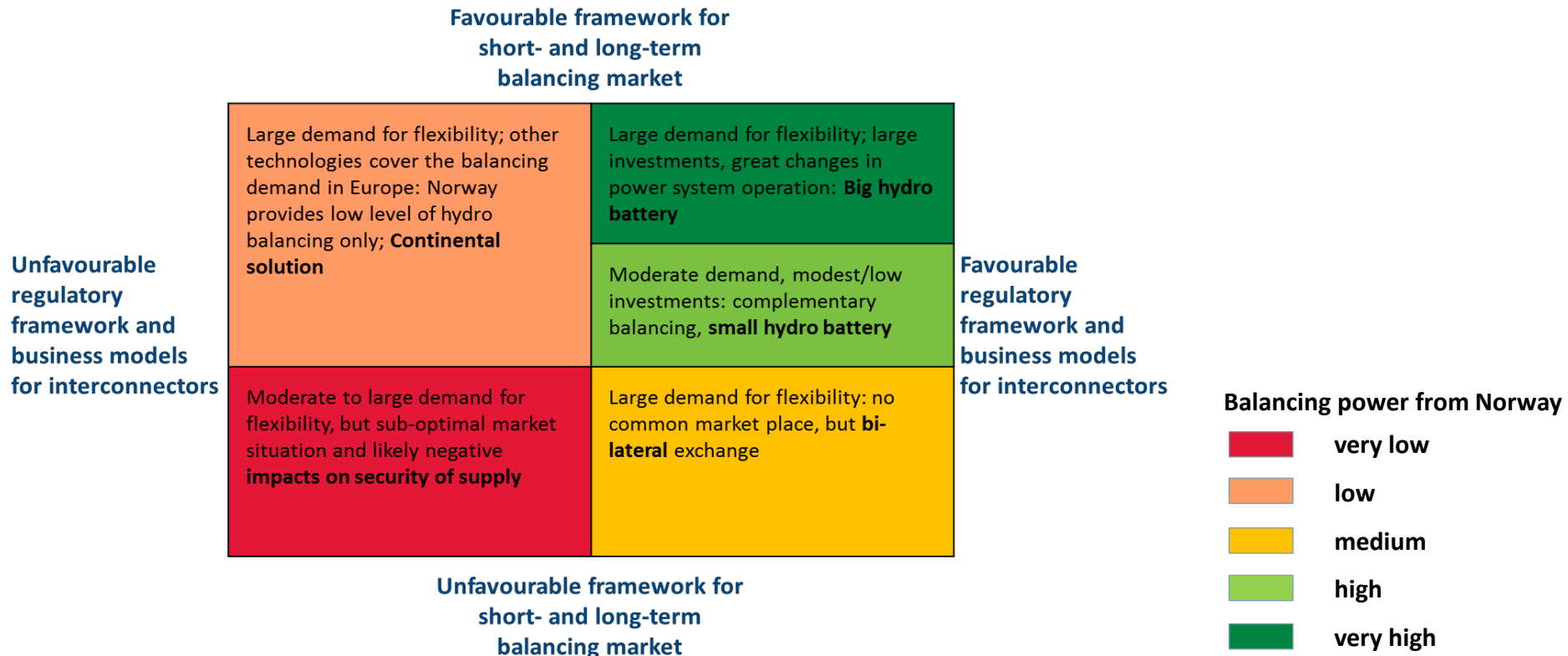
Nationalism A:

EU policy leads to national markets. Norway does not promote interconnection with EU. Large demand, but alternative technologies provide flexibility to EU.

Results from the workshop (III)

Most important uncertainties:

1. Power market: Framework for short, medium and long term balancing
2. Regulatory regime and business models for interconnectors
3. Demand for flexibility from Norwegian hydropower



Conclusions

- All scenarios build on the following most important uncertainties:
 - Market framework and business models, market integration
 - Level of competition between flexible technologies on European market
 - Share of VRES
 - Demand for flexibility from Norwegian hydropower
 - EU and national policy
- What is a consequence of policies?
- What is considered as prerequisite?

Further work

- Selection of most important uncertainties to be used in scenarios for the project
- Description of scenarios
- Cross-check on consistency with other relevant scenarios
- Build data models



Thank you for your attention

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Renewable Energy (CEDREN)

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